Crystal – Loon – Mills Lakes Watershed
CWP Project
Quality Assurance Project Plan

Prepared for:

Minnesota State University – Mankato
Water Resources Center
184 Trafton Sciences Center South
Mankato, Minnesota 55601

Final

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A1. APPROVAL SIGNATURE PAGE

By their signatures below the undersigned attest that they are familiar with the requirements of this document and agree to fulfill their responsibilities as specified herein.

_____ _____

Sarah Duda, Project Coordinator Date

_____ _____

Paul Davis, Project Manager, MPCA Date

_____ _____

Roger Fisher, WQ QA/QC Coordinator, MPCA Date

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Table 1. Acronyms and Abbreviations

APG : Analytical Products Group, Inc., Belpre, OH
AUID : Assessment Unit Identification Number
CD : County Ditch
CLM : Crystal-Loon-Mills
DQO : Data Quality Objective
DI : Deionized
Eh : Oxidation-Reduction Potential
EPA : Environmental Protection Agency
ERA : Environmental Resource Associates, Arvada, CO
EWI : Equal Width Increment
EDI : Equal Depth Increment
FD : Field Duplicate
H_2SO_4 : Sulfuric Acid
HUC : Hydrologic Unit Code
LIMS : Laboratory Information Management System
µ : Micron
µg : Microgram
mg : Milligram
MDH : Minnesota Department of Health
MPCA : Minnesota Pollution Control Agency
PM : Project Manager
QA : Quality Assurance
QAC : Quality Assurance Coordinator
QAM : Quality Assurance Manual
QAPP : Quality Assurance Project Plan
QC : Quality Control
RPD : Relative Percent Difference
RSD : Relative Standard Deviation
SB : Sampler Blank
SM : *Standard Methods* (*for the Examination of Water and Wastewater*)
SOP : Standard Operating Procedure
STORET : STOrage and RETrieval [federal database]
TB : Trip Blank
TP : Total Phosphorus
WQ : Water Quality
WRC – MSUM : Water Resources Center – Minnesota State University, Mankato

DOCUMENT CONTROL

This document has been prepared according to the United States Environmental Protection Agency publication, *EPA Requirements for Quality Assurance Project Plans*, dated March 2001 (QA/R5). This QAPP will be reviewed annually and updated as needed. Updated versions of this QAPP will bear a new (x + 1) revision number. Sarah Duda will assume responsibility for archiving outdated versions of this QAPP which will be kept at project headquarters. Archived versions of this QAPP will be retained for a minimum of ten years from the date of archival.

GROUP A. PROJECT MANAGEMENT

A3. DISTRIBUTION LIST

Each person listed on the Approval Signature Page and each person listed in Table 2 will receive a copy of the final approved version of this Quality Assurance Project Plan. A copy will also be made available to other persons taking part in the project and to other interested parties.

Table 2. Crystal-Loon-Mills Lakes Watershed CWP Project QAPP Distribution List

Name	Title/Affiliation	Address	Phone/e-mail
Sarah Duda	Project Coordinator, MSU – Mankato, Water Resources Center	184 Trafton Sciences Center South, Mankato MN 55601	507.389.2299; sarah.duda@mnsu.edu
Scott Matteson	Project Sampling Leader, MSU – Mankato, Water Resources Center	184 Trafton Sciences Center South, Mankato MN 55601	507.389.5338; scott .matteson@mnsu.edu
Paul Davis	Project Manager, MPCA	12 Civic Center Plaza, Ste 2165 Mankato, MN 55601	507.344.5246; paul.davis@state.mn.us
Pat Baskfield	Hydrologist, MPCA	12 Civic Center Plaza, Ste 2165 Mankato, MN 55601	507.344.5240; pat.baskfield@state.mn.us
Roger Fisher	WQ QA/QC Coordinator, MPCA	520 Lafayette Road North, St. Paul, MN 55155-4194	651.296.7387; roger. fisher@pca.state.mn.us

A4. PROJECT ORGANIZATION

Table 3. Crystal-Loon-Mills Lakes Watershed CWP Project Personnel

Name/Title	Project Responsibility
Sarah Duda, Project Coordinator	Project Decisions; QA/QC; Data Validation; MPCA Liaison
Scott Matteson, Project Sampling Leader	Field and Sampling Activities; Field QC
Paul Davis, MPCA Project Manager	Technical Assistance, Data Review
Pat Baskfield, MPCA Hydrologist	Technical Field Support
Roger Fisher, WQ QA/QC Coordinator	QA/QC Support

The MPCA QA/QC Coordinator (QAC) is independent from project staff, including those that generate data. The extent of the QAC role is to assist in the writing of this QAPP and to be

available to address project QA/QC problems and concerns. The QAC is not accountable to anyone directly or indirectly associated with this project.

Sarah Duda is responsible for maintaining the latest official approved version of this QAPP.

A5. PROBLEM DEFINITION/BACKGROUND

A5.1 Crystal-Loon-Mills Lakes Watershed CWP Project Background

The Crystal-Loon-Mills Lakes (CLM) watershed is located in Blue Earth County in south central Minnesota. The CLM system is part of the Minneopa Creek watershed which, in turn, is part of the Middle Minnesota River Basin.

The CLM system consists of two minor sub-watersheds draining approximately 13,799 acres and includes three lake basins: Crystal Lake (393 acres), Loon Lake (755 acres), and Mills Lake (229 acres). There are three public access sites in this system: one city-owned on Crystal Lake and one state-owned on each of Loon and Mills Lakes.

Sub-watershed 28045 covers 14.8 sq. mi. and is drained by County Ditch (CD) 56 which was constructed in 1920. Most of the watershed drains through CD 56 into Lake Crystal. In addition, 75% of the urban residential areas for the City of Lake Crystal are drained into CD 56 through several storm sewers.

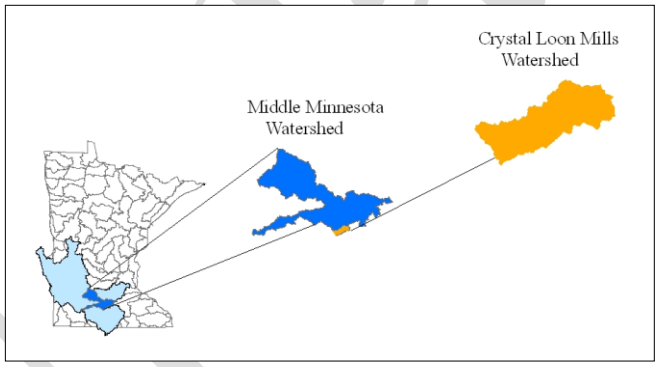

Figure 1. Crystal-Loon-Mills Lakes Watershed
(To view in greater detail, enlarge this graphic to 150% using the zoom feature in the overhead toolbar)

A Phase I Clean Water Partnership (CWP) diagnostic study performed in 1995 indicated the major water quality concern is excess phosphorus from the rural areas of the watershed. Crystal Lake receives surface water from two primary sources, CD 56 and the Loon Lake outlet. The study found CD 56 to be the major contributor of nutrients and sediment to Lake Crystal. CD 56 drains agricultural land to the southwest of Crystal Lake and then enters the City of Lake Crystal before discharging into the lake. The study determined that the agricultural portion of this ditch watershed contributed 90% - 95% of the phosphorus load to the lake. Thus, the recommendation of the study was to focus on rural best management practices (BMPs) to reduce nutrient and sediment transport to the lake.

A5.2 Crystal-Loon-Mills Lakes Watershed CWP Project Problem Definition

In 2006, Crystal Lake was listed on the 303(d) impaired waters list for excess nutrients. In September 2004, Crystal Lake experienced a toxic algae bloom due to very high levels of nutrients. In addition, the Crystal Lake swimming beach is frequently closed due to high concentrations of fecal coliform bacteria. Further, poor water quality can have a detrimental impact on recreational activities and lakeshore property values. Water quality improvement in the CLM system and upper Minneopa Creek would ultimately help improve water quality at Minneopa State Park.

A6. PROJECT DESCRIPTION

A6.1 Crystal-Loon-Mills Lakes Watershed CWP Project Summary

The main initial project emphasis is to develop a relevant Work Plan, coordinate various aspects of the Crystal-Loon-Mills CWP project, set up project systems, and establish relationships among partners and stakeholder groups.

Additional project elements are:

- Education and Outreach Activities
- Best Management Practices Promotion and Activities
- Monitoring
- Data Evaluation and Analysis
- Administration

For more detailed information about project activities, refer to the project Work Plan.

A6.2 Crystal-Loon-Mills Lakes Watershed CWP Project Goal

The overall goal of the Crystal-Loon-Mills Lakes CWP Project is to promote and implement positive land use changes in the watershed that will improve water quality along with promoting a healthy agricultural and recreation-based local economy. The desired environmental outcome of this project is a significant reduction in the Total Phosphorus reaching Lake Crystal. Additional goals are wildlife and aquatic habitat improvement and increased recreational use suitability.

A6.3 Crystal-Loon-Mills Lakes Watershed CWP Project Milestone Schedule

Following are project milestone monitoring tasks for 2008 – 2010. For task details refer to the project Work Plan.

Water quality monitoring will be conducted on CD 56 during field monitoring season, approximately April 1st – September 30th, 2007 – 2009. 20 – 25 samples will be taken during the monitoring season. Water monitoring parameters include stage monitoring, flow measurements,

Phosphorus, Ortho-phosphorus, Nitrate Nitrogen, Total Suspended Solids, Transparency Tube readings, *E. coli* bacteria, Dissolved Oxygen, pH and Temperature.

Crystal, Loon, and Mills Lakes will be monitored beginning in 2008. Three samples will be taken per lake. Crystal Lake will be sampled twice monthly and Loon and Mills Lakes will be sampled monthly.

A6.6 Samples for Laboratory Analysis

Water quality samples are submitted to MVTL Laboratories, Inc., New Ulm, and analyzed for the following parameters:

- Total Phosphorus
- Orthophosphorus
- Nitrate Nitrogen
- Total Suspended Solids
- *E. coli*

A6.7 Samples for Field Analysis

The following parameters will be measured in the field:

- Transparency
- Dissolved Oxygen
- pH
- Temperature

A7. QUALITY OBJECTIVES AND CRITERIA

Table 4. Laboratory and Field Measurement Parameter Objectives

Parameter	Precision (% RPD)	Range	Reporting Limits	Units	Holding Times
E. coli Bacteria	30%	0 – 2,400	0	MPN/100-mL	24 H*
Total Phosphorus	30%	0.025 – 3	0.003	mg/L	28 D
Ortho-phosphorus	30%	0.005 – 1	0.005	mg/L	28 D
Nitrate Nitrogen	10%	0.05 – 20	0.05	mg/L	28 D
Total Suspended Solids	30%	1 – 500	1.0	mg/L	7 D
Chlorophyll a	30%	10 – 400	**	µg/L	4 H***
Transparency†	---	1 – 100	---	cm	---

Dissolved Oxygen†	[0.1 mg/L]	0.5 – 14	---	mg/L	---
pH†	[0.3 SU]	7 – 9	---	Standard Units	---
Temperature†	[0.3 °C]	1 – 25	---	°C	---
Secchi Disk†	---	0 – 25	---	m	---

*8 hrs. if used for possible enforcement purposes; **Depends upon the volume filtered; ***May be stored on ice in the dark for 2 – 4 hrs. prior to analysis, otherwise, field-filter and store frozen at ≤ -20°C for no longer than 3½ weeks prior to analysis; †Field Measurement

Virtually all environmental data are only approximations of the true values of the parameters measured. These estimates are affected by the variability of the medium being sampled and by random and systematic errors introduced during the sampling and analytical procedures.

Data Quality Objectives (DQOs) are qualitative or quantitative statements of:

- Precision (a measure of random error)
- Bias (a measure of systematic error)
- Accuracy
- Representativeness
- Completeness,
- Comparability, and
- Sensitivity

The DQOs must be defined in the context of project requirements and objectives not the test method capabilities.

Precision – This quality element measures how much two or more data values are in agreement with each other. Precision is discussed in the introductory chapter of *Standard Methods for the Examination of Water and Wastewater*, 20th Edition, 1998. Field sampling precision is determined by using field split samples or field duplicate samples. Laboratory analytical precision is determined by comparing the results of split samples, duplicate samples, and duplicate spike samples.
Sampling and/or analytical precision may be determined from split or duplicate samples by calculating the Relative Percent Difference (RPD) as follows:

$$\mathbf{RPD = (A - B) \div ((A + B) / 2) \times 100}$$

where A is the larger of the two duplicate sample values and B is the smaller value.

Where three or more replicate samples or measurements have been taken, calculate the Relative Standard Deviation (RSD) instead of the RPD as follows:

$$\mathbf{RSD = (s/\chi) \times 100}$$

Where **s** is the standard deviation of the replicate values and χ is the mean of the replicate values.

Bias – This expresses the degree to which a measured value agrees with or differs from an accepted reference (standard) value due to systematic errors. Field bias should be assessed by use of field blanks and trip blanks. Adherence to proper sample handling, preservation, and holding time protocols will help minimize field bias.

Since the sampling method for all sampling will be grab sampling, no field blanks (sampler blanks) will be taken. Trip blanks are taken only for VOC sampling which is not a parameter to be measured by this project. Thus bias due to field activities will not be determined. However, laboratory bias will be determined as part of its internal quality control. Bias effects that fall outside the laboratory's acceptance limits will be flagged.

Accuracy – This expresses the degree to which an observed (measured) value agrees with an accepted reference standard (certified sample value) or differs from it due to systematic errors.

Completeness – Expressed as the number of valid (usable) data points made to the total number of measurements expected according to the original sampling plan. Percent completeness is determined separately for each parameter and is calculated as follows:

% Completeness = (no. of usable data points ÷ no. of planned data points) x 100

High or low water levels may reduce the number of samples that can be taken. This may be compensated for by scheduling additional sampling events or sampling as near to the original sampling site as possible. Any such variances to the established sampling protocol will be thoroughly documented. Resulting data will also be qualified to reflect this.

Representativeness – This expresses the degree to which data accurately and precisely represents parameter variations at a sampling point, or of a process or environmental condition. Representativeness of field data are dependent upon proper sampling program design and is maximized by following the sampling plan, using proper sampling protocols, and observing sample holding times.

Data will also be compared to historical project data and to current and historical data generated by other organizations

Comparability – This represents the level of confidence with which the project data set can be compared to other data. Indicate the steps to be taken to ensure the comparability of field measurements and laboratory analyses. Comparability is dependent upon establishing similar QA objectives for the sets being compared and is achieved by using similar sampling and analytical methods.

Sensitivity – For laboratory analyses this represents the lowest level of analyte that can be reliably detected by the laboratory analytical method. For field measurements this represents the lowest level of analyte the field analytical method or meter can reliably detect.

Table 5. MVTL Laboratories Inc., Analytical Parameters

Parameter	Sample Quantity	Sample Container	Preservative	Holding Time	Analytical Method
E. coli Bacteria	100 mL	Plastic	$Na_2S_2O_3$; Cool to 4°C	24 H*	SM** 9223 B Colilert Quanti-Tray
Total Phosphorus	100 mL	Plastic	H_2SO_4 to pH <2; Cool to 4°C	28 D	EPA 365.1 rev. 2.0
Ortho-phosphorus	100 mL	Plastic	Cool to 4°C	28 D	EPA 365.1 rev. 2.0
Nitrate Nitrogen	100 mL	Plastic	Cool to 4°C	28 D	EPA 353.2 rev. 2
Total Suspended Solids	100 mL	Plastic	Cool to 4°C	7 D	USGS I-3765-85
Chlorophyll a	1 L	Amber glass	Cool to 4°C	4 H†	SM 10200 H

*8 hrs. if used for possible enforcement; **Standard Method for the Examination of Water and Wastewater, 20th Ed.

A8. SPECIAL TRAINING/CERTIFICATION

Training of Crystal-Loon-Mills Lakes Watershed CWP Project staff is done through assistance from knowledgeable Water Resources Center – Minnesota State University, Mankato (WRC – MSUM) staff, the MPCA Project Manager, and the MPCA Hydrologist. Sarah Duda is responsible for field sampling training and monitoring oversight.

Sarah Duda is responsible for ensuring key project staff have or receive adequate training to effectively and correctly perform their project duties. Key staff includes the Project Coordinator, Project Manager, Hydrologist, samplers, sample handlers, data reviewers, and data assessors. They are also responsible for documenting such training and maintaining the training records.

A9. DOCUMENTATION AND RECORDS

All versions of the QAPP are retained in the WRC – MSUM office. Crystal-Loon-Mills Lakes Watershed CWP Project staff retains sampling sheets for five years. Data are entered into STORET by MPCA staff.

Sampling sheets are completed on-site at the time of sampling.

Sampling collection records, field notebooks, and all records of field activity are retained by the Crystal-Loon-Mills Lakes Watershed CWP Project staff for five years following completion of the project.

GROUP B. DATA GENERATION AND ACQUISITION

B1. SAMPLING PROCESS DESIGN

WRC – MSUM staff and MPCA staff in consultation with project partners developed the sampling plan.

Water chemistry and physical data are collected and used to monitor project effectiveness. Samples taken during the project are considered a snapshot of current water quality conditions. Long-term monitoring programs need to be established to truly measure water quality improvements.

B2. SAMPLING METHODS

All field work for this project, including collection of water samples and delivery of water samples within the required time frame to MVTL Laboratories, Inc. (MVTL), are conducted by WRC – MSUM staff. A certified laboratory conducts all water sample analyses. This QAPP supports the laboratory's QAM and SOPs and is specific for the Crystal-Loon-Mills Lakes Watershed CWP Project.

Water chemistry field duplicates and sampler blanks are collected 10% of the time for the lake water quality samples. All samples are collected using approved methods and sampling devices. Samples are transferred from sample collection devices to pre-cleaned polyethylene or glass bottles. WRC – MSUM staff are responsible for collection and transport of the samples to MVTL. MVTL provides the pre-cleaned bottles for obtaining the lake water quality samples.

Grab and Remote Samples

Water quality samples are collected using clean polyethylene bottles of appropriate size to provide the laboratory with sufficient sample to perform the requested analyses and reanalysis, if necessary. All samples are preserved as required, labeled with a unique identifier, and placed in a cooler on ice. Sample information is logged on field data sheets.

Regardless of collection method, the sample is stored and transported in a clean, labeled container. The clean container supplied by the analyzing laboratory is not rinsed before the sample is collected.

B3. SAMPLE HANDLING AND CUSTODY

Scott Matteson is the field sample custodian and keeps records of all samples taken by field personnel. Sample bottles are labeled with bottle number, site identification, and date. They are sealed tightly and packed in a cooler on ice at the sampling location. The field record includes project name, sampler's signature, unique station identification number, sample number, parameters for laboratory analysis, matrix, number and size of containers, and date and time. All laboratory samples are typically delivered to MVTL within 24 hours of collection. Coolers containing samples that require ice preservation are checked periodically to ensure samples remained adequately iced so sample temperatures do not exceed 6°C.

Information on field conditions, such as the weather, deviations from written procedures, operating condition of the equipment, and other unusual occurrences are also recorded for each sampling event.

Laboratory Sample Handling

Sample containers are provided by the laboratory. Container cleanliness is verified by QA/QC procedures as specified in the laboratory's QAM and SOPs. The laboratory verified sample bottle cleanliness is by running a specified number of bottle blanks on each shipment received and on each batch of sample bottles following laboratory cleaning and sterilization. A preservative is added to specific bottles, as required, or accompanies the bottles in a separate container. Preservatives used and their volumes and concentrations are specified in the laboratory QAM.

Temperature blanks are included in the coolers provided by the laboratory to verify whether the appropriate sample temperature of $\leq 6°C$ has been maintained.

Upon arrival at the laboratory, the condition of the samples is determined. The samples are checked for leaks and appropriate preservation and the temperature taken. The information is recorded on the sample identification sheet. The sample identification sheet information is then compared to the information on the sample bottles and any discrepancies are noted. The samples are then logged into the Laboratory Information Management System (LIMS). They are assigned two identification numbers, a work order number and a unique laboratory number. The samples were then stored in the appropriate area as determined by required storage temperature, matrix, and analyses required. The laboratory sample storage areas are monitored daily.

Samples are tracked using LIMS. Any problems encountered are reported to the client. An analytical report is printed out. The samples are held until their holding time has expired or until 30 days after completion of the analysis. Samples are then disposed of in an environmentally acceptable manner. Samples are returned to the client if requested. Water samples that are environmentally safe are disposed into the local sanitation system. Samples that contain hazardous waste may be returned to the client for proper disposal.

Analytical Standard Operating Procedures (SOPs) are part of the laboratory QAM.

Field Information Sheets

Field data sheets are the primary method for documenting most stream monitoring field activities. These sheets served as an initial record of any field measurements and weather conditions at the time of sampling.

Field Notes

Field notes are used to document important information during sampling events. They are entered into a bound notebook with waterproof pages. Entries are made using pens with indelible ink. The field notebook becomes part of the project data and is retained with the analytical data hard copies and other project documents.

Sample Labeling

Each sample container has a label attached which is filled out in its entirety. Sample containers without labels or labels that are missing information are not, as per laboratory policy, accepted by the laboratory. The sample label includes the water body code or name, the site number, the date, and time of sample collection.

Sample Shipping

All samples are packed in an ice-filled cooler for transport to the laboratory. Samples are typically transported within 24 hours of collection.

B4. ANALYTICAL METHODS

Analytical protocols are found in the MVTL QA/QC Manual and SOPs. Analytical accuracy is routinely checked by the laboratory's analysis of standard certified reference analytes.

TABLE 6. MVTL Laboratories, Inc. Analytical Methods

Parameter	Method
E. coli Bacteria	SM 9223 B; Colilert Quanti-Tray
Total Phosphorus	EPA 365.1 rev. 2.0
Ortho-phosphorus	EPA 365.1 rev. 2.0
Nitrate Nitrogen	EPA 353.2 rev. 2
Total Suspended Solids	USGS I-3765-85
Chlorophyll a	SM 10200 H

All raw data generated in the laboratory are recorded in bound notebooks, on project specific raw data sheets, MVTL custom logbooks, or as an instrument printout. This data includes sample numbers, calibration data, calculations, results, analyst notes and observations, quality control data, date of analysis, and initials of the analyst. Completed notebooks are returned to the Quality Assurance Unit where they are archived. Chromatograms, graphs, and strip charts, if part of the data package, are kept with the laboratory raw data. All items are labeled, dated and signed by the analyst. When completed, the data are integrated into a final report.

For out-of-control situations, a corrective action plan is in place. The initial action is to repeat the analyses of the samples bracketed by the unacceptable quality control sample. Replication of unacceptable results is investigated as a matrix effect by reviewing blank spikes or laboratory knowns. If the quality control samples are still unacceptable, the entire process is repeated. This includes sample preparation or extraction. If re-analysis is not possible due to the sample being past holding times or sample quantity is insufficient, documentation of the situation will be added to the raw data. In these cases, the client is notified and the report flagged.

B5. QUALITY CONTROL

Where applicable, internal reference standards will be analyzed and recorded with each sample run. External reference standards and standard reference material obtained from ERA, APG, or another approved provider will also be used. All stock standard solutions will be properly labeled, stored, and expiration dates visibly recorded on the label. The measured data for the

certified standards must fall within the specified range as given by the provider or corrective action will be taken.

The Minnesota Department of Health (MDH) certifies MVTL Laboratories, Inc. As such the laboratory is subject to audit by MDH and MPCA.

One field QC grab sample duplicate for laboratory analysis is collected at the sampling site for every ten like samples taken. The field duplicate for laboratory analysis is collected to determine sampling and laboratory analytical precision.

If QC samples revealed a sampling or analytical problem, field and laboratory personnel attempt to identify the cause.

Upon working out a plausible solution, personnel take necessary steps to ensure that similar problems do not arise during future sampling events. If possible the sampling event is repeated. As per laboratory protocol, suspect data are flagged or qualified depending upon the nature and extent of the problem.

MVTL implements specific QA/QC methods and procedures for dealing with out-of-control situations. These are documented in MVTL's QAM and SOPs, copies of which are maintained on file at MPCA and available for consultation and review upon request.

B6. INSTRUMENT/EQUIPMENT TESTING, INSPECTION, AND MAINTENANCE

All hand-held instruments, when used, are inspected and tested each sampling day prior to their use in the field. Steps are taken to fix any instrument problems noted during testing. If any problems cannot be resolved the instrument is taken out of service and a substitute instrument is used. pH buffer solutions are replaced with fresh solutions before the buffer solution expiration date. Batteries for all meters are routinely checked and replaced when meters showed power-related problems. Spare batteries for all instruments are taken on all sampling trips. All maintenance procedures are documented in the meter maintenance logs or the field notebook.

B7. INSTRUMENT/EQUIPMENT CALIBRATION AND FREQUENCY

All field instruments, if used, are calibrated each sampling day before being taken into the field. Instrument calibration is checked periodically throughout the sampling day and recalibrated if necessary. All instrument calibration checks and procedures are documented on the instrument maintenance log or in the field notebook.

The Transparency Tube and Secchi disk, both used in this project, are not subject to calibration, as such.

B8. INSPECTION/ACCEPTANCE OF SUPPLIES AND CONSUMABLES

Supplies and consumables included paper supplies, gloves, deionized water, and batteries. Supplies and consumables are purchased only from reputable and reliable suppliers and inspected for usability upon receipt.

B9. DATA ACQUISITION REQUIREMENTS (NON-DIRECT MEASUREMENTS)

Project staff reviewed historical water quality data collected by previous assessment projects and used the data for comparative and modeling purposes along with the data from this project.

Nutrient and sediment loads and flow weighted mean concentrations for CD 56 will be computed using FLUX modeling. Nutrient and sediment loads will also be computed for the County Road 9 site using FLUX modeling and associated analyses. Lake monitoring data – Phosphorus, Ortho-phosphorus, Secchi disk, and Chlorophyll-a – will be assessed using BATHTUB modeling and the Carlson Trophic Index. BATHTUB will be used to calculate the percent reduction in nutrient loads needed to reach project goals.

B10. DATA MANAGEMENT

The Project Coordinator is responsible for completing the field data sheets. This information is entered into a spreadsheet or database and archived. Laboratory results are entered into a computer database and/or spreadsheet which are maintained by the Project Manager who also assists with data maintenance, reduction, and transmittal. The MPCA Project Manager also reviews all data prior to its approved entry into STORET.

Quality assurance data sheet checks include scanning for apparent entry errors, measurement errors, and omissions. Suspect data are flagged and/or excluded from use. Data may be presented in table, graph, and chart format. Unusual data are rechecked to verify its accuracy. The data are then entered into STORET by MPCA data entry personnel.

Data collected is analyzed on an annual basis with in-depth analysis and modeling being conducted at least once during the project. Flow/discharge curves are created for Lake Crystal. Flow and nutrient loading are determined for Crystal Lake through use of a modeling program. Modeling based on water chemistry data is completed by the WRC – MSUM with assistance from the MPCA. All data are collected and analyzed in accordance with this QAPP. The WRC – MSUM provides the data and modeling results to project partners and makes it available to the public.

GROUP C: ASSESSMENT AND OVERSIGHT

C1. ASSESSMENT AND RESPONSE ACTIONS

Sarah Duda as Project Coordinator is responsible for all field activities, reviewing the data, reporting to the group on findings, and forwarding all data to the appropriate state regulatory agency for inspection and input into STORET. She oversees and assesses all field sampling and data collection. The MPCA Project Manager and QA staff are also authorized to oversee field

activities during this project. The MPCA Project Manager and WQ QA/QC Coordinator are also authorized to follow up on sampling activities during the project.

C2. REPORTS TO MANAGEMENT

A draft report of the Crystal-Loon-Mills Lakes Watershed CWP Project findings is prepared for the MPCA and shared with all involved watershed districts, local resource managers, and other involved parties.

Meetings and conference calls with technical committee members are held throughout the project. Semi-annual reports including project and budget updates are also submitted by the Project Coordinator to the MPCA PM. A final report will be submitted to the MPCA project manager following project completion.

Problems that arise during the project are corrected and reported to all parties involved in the project.

WRC – MSUM staff are responsible for the reporting, tracking, and overall management of the Crystal-Loon-Mills Lakes Watershed CWP Project.

All data are recorded and tracked through use of the Microsoft Excel database management system. The data compiled during this project is incorporated into spreadsheets and sent to the MPCA for perpetual storage in STORET, the EPA environmental database.

GROUP D: DATA VALIDATION AND USABILITY

D1. DATA REVIEW, VERIFICATION, AND VALIDATION

All raw data are transcribed to the data transmittal form and stored in a binder-type notebook. Where applicable, the data is organized electronically and filed in the MPCA STORET database. Statistical analyses on replicate samples are recorded so that the degree of certainty can be estimated.

All data are reviewed by the project monitoring coordinator and signed by the analyst. Copies of the data transmittal form and all pertinent records of calibration, standardization, and maintenance will be archived.

All laboratory analytical results are cross-checked against the field notebook and sample tags to ensure that the raw, computer-generated summary of the laboratory analyses are assigned to the correct sampling stations. All analytical results are compared to the field sheets to ensure that the data are complete.

Field data and field QC sample sets are reviewed by Sarah Duda to determine if the data meets the DQO and QAPP objectives. In addition, Paul Davis**,** MPCA Project Manager, assists in the

data review. Data is examined and outliers identified through statistical analysis. Decisions to reject or qualify data are made by Sarah Duda and Paul Davis.

D2. VERIFICATION AND VALIDATION METHODS

Project staff follow the EPA *Guidance on Environmental Verification and Validation* (EPA QA/G-8) whereby the data are reviewed and accepted or qualified by project and/or MPCA staff.

D3. RECONCILIATION WITH USER REQUIREMENTS

Within 48 hours of receipt of results of each sampling event, calculations and determinations of precision, completeness, and accuracy are made and corrective action implemented, if needed. If data quality does not meet project specifications, the deficient data is flagged or discarded and the cause of failure evaluated. Any limitations on data use are detailed in the project reports and other documentation.

Project data is compared to historic data and is also used as complimentary data for other monitoring efforts within the basin.

For the data to be considered valid, data collection procedures, the handling of samples, and data analysis must be monitored for compliance with all the requirements described in this QAPP. Data is flagged and qualified if there is evidence of habitual violations of the procedures described in this QAPP. Any limitations placed on the data are reported to the data end user in narrative form.

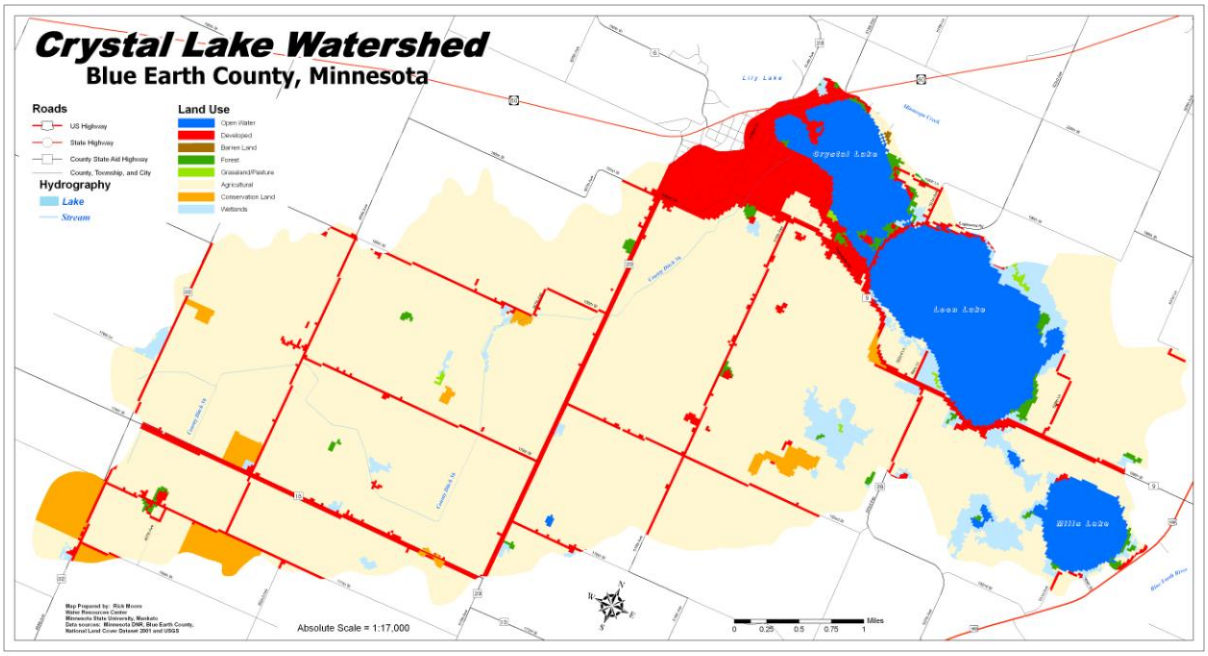

Figure 2. Crystal-Loon-Mills Lakes Watershed -- Land Use (Detailed)

(To view in greater detail, enlarge this graphic to 150% using the zoom feature in the overhead toolbar)

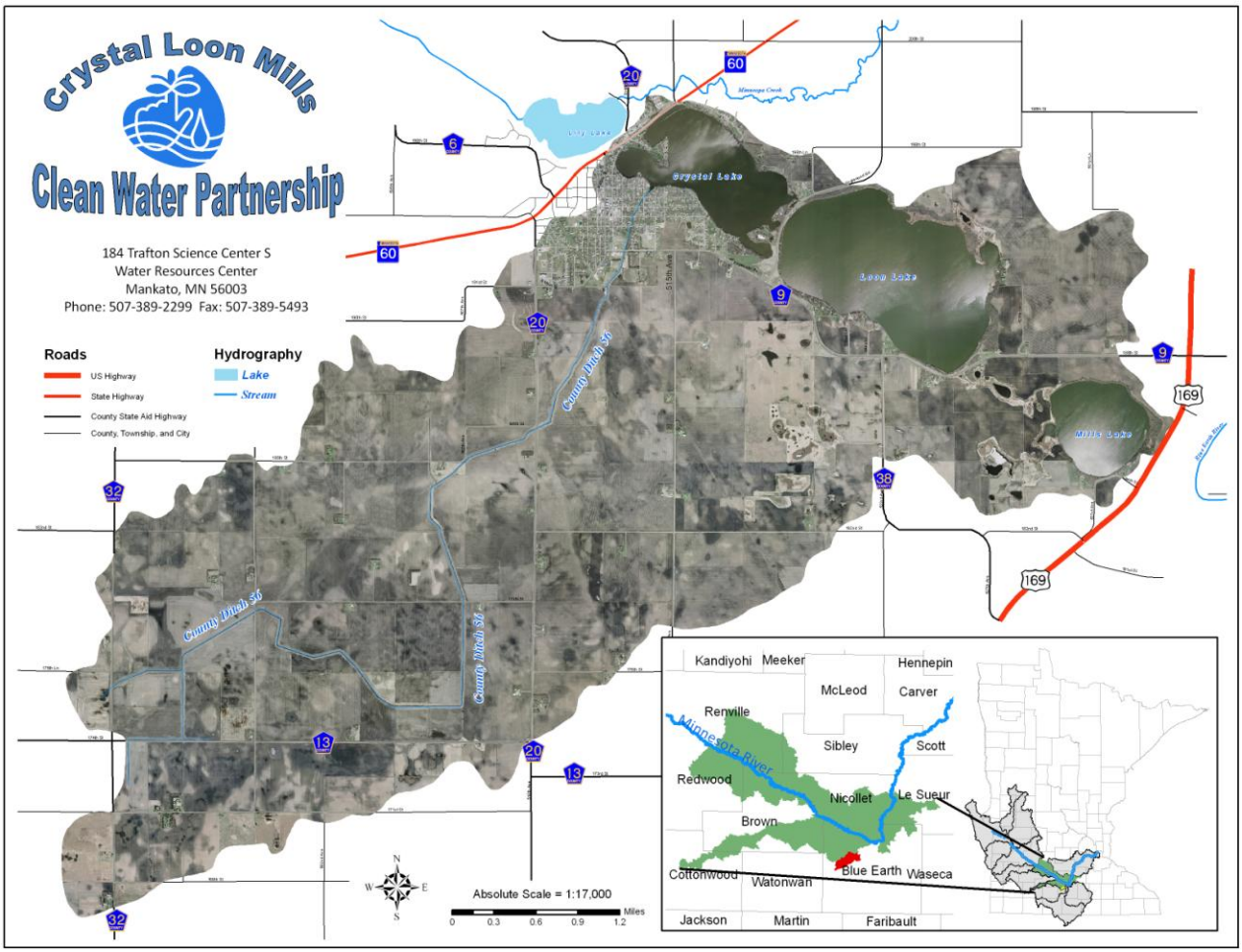

Figure 3. Crystal-Loon-Mills Lakes Watershed (Detailed)

(To view in greater detail, enlarge this graphic to 150% using the zoom feature in the overhead toolbar)

Appendix A

Hand-Collected (Grab) Sampling

Standard Methods for Collection

Water is collected at the sampling point using one of the following methods depending upon physical accessibility:

- Triple sampler (MPCA design)
- Remote grab sampler (MPCA design - 2-liter Nalgene™ bottle clamped to a telescoping pole)
- Sample bottle dip while wading
- Sample bottle dip through hole cut in ice
- Kemmerer Sampler

Follow bottle rinse and preservation methods as directed by the analyzing laboratory. The Minnesota Department of Health recommends that its bottles **not** be rinsed before sample collection. MDH sample bottles are pre-cleaned, disposable. Also, each lot is sampled for cleanliness as part of MDH's QA/QC Program. Repeat-use sampling equipment chambers that contact sample water should be rinsed thoroughly with sample water three times before water is collected to transfer to sample containers.

When grab sampling is suitable, samples should be collected along the sample site cross-section. Sample at a point that best represents the water quality of the total flow at the cross section. Avoid sampling points that are poorly mixed or affected by local temporary conditions such as ponding across part of the stream width, obviously disproportionate sediment load, or backwater conditions. If a site is poorly mixed across the stream, integrated sample across the stream width should be used, or another site should be chosen that is well mixed across the stream width.

Collect the sample at a middle depth in the water column without disturbing stream bed sediments or collecting floating materials from the surface. When grab sampling, the bottle should be lowered mouth down to the middle depth below the water surface then turned upward to collect the sample. Always stand downstream of the sampling point to avoid contaminating the sample. During ice conditions, keep ice and snow out of the sampling hole cut in the ice.

SAFETY FIRST!

If wading, as a general rule, if stream depth (in feet) multiplied by its velocity (feet/second) is greater than your height (in feet), and then **DO NOT WADE!**

(Stream Depth) [ft.] x Stream Velocity [ft./sec.] > your height [ft.] = Do Not Wade!

Appendix B

QA Field Sampling Procedures

Sampler Blanks

A sampler blank (also commonly referred to as a rinsate blank or an equipment blank) is a sample of distilled water that is rinsed through the sampling device and collected for analysis. The first step in collecting a sampler blank is to decontaminate the sampling device in the same manner that is used to collect your regular samples. For example, if you clean the sampling device with detergent and rinse with DI water, then conduct this same procedure before you collect the blank. **If you normally rinse your sampling device with sample water before collecting your sample, then conduct this rinse with DI water instead of sample water** – this will prevent any residual sample water from being detected in your results. Try to eliminate as much of the rinse water from the sampling device as possible before you collect the blank.

To collect the blank, fill the sampling device with distilled water and transfer the water to the appropriate collection bottles. Handle the device as close to your normal sampling procedure as possible: agitate the sampling device in the same manner, try to leave the water in the sampling device for the same amount of time, and collect the same volume of water.

Trip Blanks

Trip Blanks are sample bottles of deionized water that are filled before going out into the field and are carried along the entire sampling trip in the cooler. They are typically obtained ahead of time from the laboratory and are preserved in the same manner as the regular sample. Trip blanks are generally only used when collecting samples for volatile organic compounds.

Field Duplicates

A field duplicate is a second sample taken right after an initial sample in the exact same location. Field duplicates assess the sampler's precision, laboratory precision, and possible temporal variability. The duplicate sample should be collected in the exact same manner as the first sample, including the normal sampling equipment cleaning procedures.

Lab Sheets

A column labeled "QA Type" has been added to the lab sheets. If you are collecting a QA sample, fill in the type of QA sample in this column. Leave the column blank if it is a normal sample. The abbreviations for the QA samples are as follows:

SB = sampler blank FD = field duplicate TB = trip blank

The sampler blanks and field duplicate samples will have the exact same station, date, time, depth, and substation as the samples with which they are associated. The only thing distinguishing the samples apart will be the specified sample type in the "QA Type" column. So please remember to fill in this column with the QA sample type (SB or FD). Since the trip

blanks are associated with an entire sampling trip, these samples will not have a station or time associated with them. Fill in the date of the trip and the QA sample type (TB).

Appendix C

Chlorophyll a Sampling

Collect two liter samples with the two meter depth-integrated sampler. Sample bottles should be immediately placed in ice cooler (ice to 4°C) after collection. Samples should be kept out of sunlight.

Filtering should take place as soon as possible after sample collection. Portable equipment facilitates the implementation of this procedure on shore or back at the office.

- Set up filtering equipment. This will include placing a filter (0.45 µ, glass-fiber) on the funnel base with a forceps and twisting on the funnel. The funnel drains into a two liter vacuum flask.
- Measure out a known quantity of sample in a graduate (50 – 1,000 mL) depending on the observed population of algae in the lake. Filter enough sample so the filter is just a light green color.
- Pour sample into filter funnel and begin filtering sample through apparatus described above.
- After known sample has been filtered, use a squirt bottle of deionized water to wash down any algae that may be clinging to the side of the funnel. Continue filtering until filter looks dry.
- Remove vacuum and take apart filter funnel apparatus.
- Fold filter in half with forceps (do not touch with fingers) and place in Petri dish.
- Close Petri dish and write the following information on the Petri dish with a permanent marker.

    - Lake name and ID number
    - Site location
    - Date and time of sample
    - Amount of sample filtered

- Wrap Petri dishes with aluminum foil and place sample in special dry ice cooler which contains about 5 – 15 lbs. of dry ice and transport to laboratory as soon as possible.

Appendix D

The Secchi Disk

The Secchi disk originated with Fr. Pietro Angelo Secchi, an astrophysicist, who was requested to measure transparency in the Mediterranean Sea by Commander Cialdi, head of the Papal Navy. Secchi was the scientific advisor to the Pope. Secchi used some white disks to measure the clarity of water in the Mediterranean in April of l865. Various sizes of disks have been used since that time, but the most frequently used disk is an 8-inch diameter metal disk painted in alternate black and white quadrants.

The Secchi disk is used to measure how deep a person can see into the water. It is lowered into the lake by unwinding the waterproof tape to which it is attached and until the observer loses sight of it. The disk is then raised until it reappears. The depth of the water where the disk vanishes and reappears is the Secchi disk reading. The depth level reading on the tape at the surface level of the lake is recorded to the nearest foot.

Even though the Secchi disc measurement of water clarity is an approximate evaluation of the transparency of water, it is used primarily for its simplicity. A more accurate measurement of underwater irradiance can be made by the use of photometer, but that degree of accuracy is usually unnecessary.

Taking Secchi Disk Readings

The greatest value of the Secchi disc measurements occurs when each lake compares its own readings from week to week, month to month, and season to season. No comparisons between lakes should be made unless similarities in measurements are followed vigorously. Several factors are involved, such as the eyesight of the viewer, the time of day the readings are taken, the reflectance of the disc, the color of the water, and clay particles or other materials suspended in the water.

Some of the reports for any one season may show an increased water transparency depth after the first week of spring. This may be due to:

1. Reduced nutrient input from the watershed.
2. Increased grazing of algae by zooplankton.
3. Reduced soil erosion into the lake.
4. Seasonal algae succession.

If the Secchi Disk transparency depths are getting shallower during the summer season, it may be due to one or more of the following:

1. Increased abundance of free floating algae.
2. Erosion of the shoreline or erosion from site development near the lake.
3. Recirculation of bottom sediment from motorboat activity.

4. Discoloration of the water from wetland runoff and/or plant decomposition.
5. Increased turbidity.
6. Reduced zooplankton populations.

Most lakes will experience increased boat activity on weekends and holidays. Taking Secchi readings on Mondays and the day following a holiday and comparing these readings with other readings at other times may reveal the effect of boating activity on transparency depths.

Significant storm events within the watershed with the resultant storm water runoff could cause lower Secchi disk readings. Comparing Secchi disc readings immediately after a storm with readings between storms may suggest that runoff is increasing turbidity and, therefore, shallower transparency readings.

If the zooplankton populations have dropped off reducing the grazing of algae, the increase of algae will result in reduced Secchi disk readings. Dr. Robert Carlson, writing in News CLIPs, published by The Citizen Lake Improvement Program of Ohio, "If you find a sharp increase in transparency in May or June, it might be that tiny grazing animals, called zooplankton ('animal drifters') are eating the algae. When zooplankton are abundant, they can actually be seen as tiny black dots swimming over the Secchi disk.

Secchi Data Contributes to Lake Management

Nearly all Secchi disc measurements on inland lakes will be between one and forty feet. There are some exceptions greater than forty feet. A classification of lakes according to the Secchi disc measurements is as follows:

- Oligotrophic -- Greater than 16 feet.
- Mesotrophic -- 6.5 to 16 feet.
- Eutrophic -- Less than 6.5 feet.

One of the major reasons why Secchi disc measurements decrease from spring to fall is due to the increase of plankton; both phytoplankton and zooplankton. Since zooplankton graze on phytoplankton, e.g., algae, the Secchi disc readings may increase during the summer by the reduction of algae in the water. Algae blooms may occur when the amount of available nutrients increases faster than the macrophytes (plants rooted in the bottom of a lake) can absorb them.

As we learn more about the physical, biological and chemical processes within lakes, we will know better how to manage these lakes. Consistent measurement programs are vital to securing viable data.

Secchi Disk Data

Water clarity should be measured with the Secchi Disk once a week from May 1 to September. For maximum Secchi Disk measurement accuracy, the following conditions should be met:

1. The same person should be taking all readings since sharpness of vision varies from person to person.
2. The reading should be taken on the same day of the week, or at least not more than one day before or after the same day of the week.
3. It is preferable that the measurement be taken between 10:00 a.m. and 4:00 p.m. so that the light rays from the sky are at a similar angle each time the reading is taken.
4. Avoid taking the measurement when the lake is choppy or rough.
5. The Secchi disk measurement should be taken at the deepest part of the lake. This may be determined by viewing a bathymetric map or using a depth gage.
6. After anchoring the boat at the predetermined site, take the reading on the shady side of the boat.
7. The reading should be taken at the same location each week. In order to guarantee a sampling at the same location in the lake, a buoy may be permanently set at the site. If it is not possible to place a buoy at the site, line up two objects on the shore some distance apart (one at the shoreline) and line up two other objects on the shore and at right angles to the plane of the first two, anchor your boat and take the reading. Mark the shoreline objects and the intersect points on your map of the lake so that you will be able to find the same site the following week. If it is necessary for others to take the readings later in the season, they will be able to find the same location.

Some lake associations may want to take Secchi measurements at various parts of the lake for clarity comparisons. A Secchi Disk measures water clarity. Water clarity may be affected by three different factors: algae, sediment, and water color.

Algae may be free-floating or rooted on the bottom of lakes. Chara is an example of algae that is rooted on the bottom of lakes and often forms dense beds that rarely reach the surface. Chara may compete favorably with other kinds of plants for nutrients, thereby limiting the growth of less desirable aquatic plants.

Free floating algae may be thread-like or ball-like and may consist of a single cell or clumped together and visible to the naked eye. The majority however are very small and only visible under a microscope. Biology textbooks divide algae into the more common groups of Blue-Green, Green, Golden, Brown, and Red.

Algae are very important to a lake ecosystem. In an article that appeared in Michigan Riparian magazine, Dr. Richard Pippen wrote about the value of algae. He wrote, "Algae are the most important element and first stage in the so-called food chain. Algae contain the green pigment chlorophyll and like grasses, garden flowers, and trees are able to take energy from the sun and make food from carbon dioxide and water. Small microscopic animals eat algae and in turn are eaten by larger animals which are eaten by still larger animals until they reach the stomachs of fish. Some fish, such as minnows, feed directly upon the algae, thus directly or indirectly the algae serve as a food source for fishes and eventually us."

Secchi disk readings may show a significant decrease during the summer season due to the presence of a distinct green, brown, or red color that is likely due to the proliferation of free-

floating algae. Only when the populations become exceedingly high or are due to a preponderance of Blue-Green algae should the condition cause alarm. When this happens, the sources of nutrient input should be determined and remedial action taken.

Water color data should be recorded at the time the Secchi disk reading is taken. It will help to determine the kind of algae which predominate in the lake at that time.

The most valuable information from Secchi disk data is the graph which shows the weekly changes. Averaging the Secchi disk data for a summer season has very little immediate value. The greatest value of averaging will come when after a period of years the averages will show if the lake's water quality is remaining constant, improving or degrading.

Appendix E

Transparency Tube Field Sampling Protocol

Transparency

Collect your water sample in a clean bucket or bottle at mid-stream and depth.

1. Wading or From Stream Bank.

Always sample safely - don't wade into fast-moving water or areas of unknown depth. If you cannot sample safely, make visual observations only (Appearance). If a sample from mid-stream and depth is not possible, avoid stagnant water and sample as far from the shoreline as is safe. Try not to stir up the bottom. Face upstream as you fill your bucket. Avoid collecting sediment from the stream bottom or materials from the water surface.

2. From Atop a Bridge or Culvert.

With a rope tied to its handle, lower a bucket down to the stream and collect water. Pull the bucket back up, taking care not to bounce the rope or bucket on the side of the bridge or culvert. Take your tube readings in open conditions. Avoid direct sunlight by turning your back to the sun if necessary. Pour the water from your bucket into the tube until the symbol on the bottom is no longer visible. While looking down into your tube, open the valve at the bottom and slowly release water until you can JUST begin to make out the symbol on the bottom. Note this depth. Release a bit more water until the symbol is visible. Note this depth.

Record the average of the two depths noted in steps 3 and 4 on your data sheet to the nearest centimeter. If the symbol is still visible when your tube is full, indicate this on the data sheet, e.g., > 60 cm.

Stream Stage

Estimate the water level each time you sample. L=low; N=normal; H=high

Appearance

Each day that you sample, record the one number that best describes the appearance of stream water within one meter of your sampling site.

1A = Clear – crystal clear, transparent water
1B = Tea-colored – transparent water which has been discolored by dissolved organic matter (lignin) from up–stream bogs or wetlands
2 = Cloudy – is not quite crystal clear; is cloudy, white, or gray
3 = Muddy – cloudy brown due to high sediment levels
4 = Green – due to algae growth; indicative of excess nutrients released into the stream
5 = Muddy AND Green – a combination of cloudy brown from high sediment levels and green from algae growth

Recreational Suitability

Use the one number each day that you sample that best describes your opinion of how suitable the stream water is for recreation and enjoyment.

1 = Beautiful, could not be better
2 = Very minor aesthetic problems. Excellent for body-contact recreation, e.g., swimming, wading, frog–catching
3 = Body-contact recreation and aesthetic enjoyment slightly impaired
4 = Recreation potential and level of enjoyment of the stream substantially reduced, e.g., you would not swim but would boat or canoe
5 = Swimming and aesthetic enjoyment of the stream is nearly impossible

Appendix F

The Field Notebook

This section summarizes information, guidelines, and minimum requirements that apply generally to field measurements for all studies of water quality and the collection of basic data. Other terms commonly used for field measurements are field parameters and field analyses. Before proceeding with field work, check each field-measurement section for recommended methods and equipment, detailed descriptions of measurement and quality-control procedures, and guidelines for troubleshooting and data reporting.

Field Measurements—determinations of physical or chemical properties that are measured on-site as close as possible in time and space to the media being sampled.

Records, Field Instruments, and Quality Assurance

Field-measurement data and other field information must be recorded, either on paper or electronically, while in the field. *Reported* field measurements are defined as those data that are entered into STORET. The conventions used for reporting field measurement data are described at the end of each field measurement section.

Record field-measurement data, methods and equipment selected, and calibration information on field forms and in instrument log books.

Field forms include national or study-customized field forms and analytical services request forms; other forms and records (for example, chain-of-custody records) may be required for the study.

Instrument log books for each field instrument are required to document calibrations and maintenance.

Electronic records are maintained for each uniquely identified sampling location.

Field personnel must be familiar with the instructions provided by equipment manufacturers. This manual provides only generic guidelines for equipment use and maintenance or focuses on a particular instrument or instruments that currently are in common use. There is a large variety of available field instruments and field instruments are being continuously updated or replaced using newer technology. Field personnel are encouraged to contact equipment manufacturers for answers to technical questions.

Data Quality Objective (DQO) – Representativeness:

Field measurements should represent, as closely as possible, the natural condition of the surface water or ground water system at the time of sampling.

Field teams must determine if the instruments and method to be used will produce data of the type and quality required to fulfill study needs. Experience and knowledge of field conditions

often are indispensable for determining the most accurate field-measurement value. To ensure the quality of the data collected:

- Calibration is required at the field site for most instruments. Make field measurements only with calibrated instruments.
- Each field instrument must have a permanent log book for recording calibrations and repairs. Review the log book before leaving for the field.
- Test each instrument (meters and sensors) before leaving for the field. Practice your measurement technique if the instrument or measurement is new to you.
- Have back-up instruments readily available and in good working condition.

Data Quality Objective (DQO): Precision

Determined by taking duplicate samples. The closer the two values the better the precision. Usually expressed as Relative Percent Difference (RPD). Duplicate samples can measure:

- Laboratory analytical proficiency
- Sampling proficiency
- Analyte variability occurring at the sampling point

Data Quality Objective (DQO): Accuracy

The closer the sample value is to the true sample value, the better the accuracy. What is the *true* value of the sample?

Quality-assurance protocols are mandatory for every data-collection effort and include practicing good field procedures and implementing quality-control checks. Make field measurements in a manner that minimizes artifacts that can bias the result. Check field-measurement variability (precision) and bias (accuracy plus variability).

Requirement: Use reference samples to document your ability to make an accurate field measurement. Field teams also are encouraged to verify accuracy of their measurements at least quarterly against reference samples.

For measurements such as alkalinity made on sub-samples, check precision in the field every tenth sample by repeating the measurement three times using separate sample aliquots from the same sample volume.

Standard procedure: Before making field measurements, allow sensor to equilibrate to the temperature of the water being monitored. Before recording field measurements, allow the measurement readings to stabilize. The natural variability inherent in surface water or ground water at the time of sampling generally falls within these stability criteria and reflects the accuracy that should be attainable with a calibrated instrument.

For surface water: Allow at least 60 seconds (or follow the manufacturer's guidelines) for sensors to equilibrate with sample water. Take instrument readings until the stabilization criteria

are met. Record the median of the final three or more readings as the value to be reported for that measurement point.

For sites at which variability exceeds the criteria: Allow the instrument a longer equilibration time and record more measurements. To determine the value to be reported for that measurement point or well, either use the median of the final five or more measurements recorded, or apply knowledge of the site and professional judgment to select the most representative of the final readings.

Table 7. Stabilization Criteria for Recording Field Measurements

Standard Direct Field Measurement	**Measurement Stabilization Criteria (variability should be within the ranges shown)**
Temperature	± 0.2°C
Specific Conductance (if reading is ≤ 100 µS/cm) → (if reading is > 100 µS/cm) →	 ± 5% ± 3%
pH (meter displays to 0.01)	± 0.1 SU
Dissolved Oxygen (amperometric method)	± 0.3 mg/L
Turbidity (turbidimetric method)	± 10%

Surface Water

Field measurements must accurately represent the body of surface water or that part of the water body being studied. Field teams need to select a method to locate the point(s) of measurement and the method(s) to be used to make the field measurements

.

Normally, the point(s) at which field measurements are made correspond to the location(s) at which samples are collected. Standard procedures for locating points of sample collection for surface-water sampling are detailed in Chapter A4 of the USGS National Field Manual.

Properties such as temperature, dissolved-oxygen concentration, and Eh (Oxidation – Reduction Potential) must be measured directly in the water body (*in situ*). Properties such as pH, specific conductance, and turbidity are best measured in situ, but also may be measured in a sub-sample of a composited sample. Because determinations of alkalinity or acid-neutralizing capacity (alkalinity/ANC) cannot be made *in situ*, a discrete sample must be collected or sub-sampled from a composite.

The method selected to locate the point(s) of measurement usually differs for still water and flowing water. If the water system is well-mixed and its chemistry is relatively uniform, a single sample could be sufficient to represent the water body. Often, however, multiple points of measurement are needed to determine a representative set of field-measurement values.

Still Water

Still-water conditions are found in storage pools, lakes, and reservoirs. Field measurements usually are made *in situ* at multiple locations and depths. Alternatively, pH, specific conductance, and turbidity can be measured in a discrete sample or sub-sample. Measurement of alkalinity/ ANC must be in a discrete sample. The location, number, and distribution of measurement points are selected according to study objectives.

Locating Point(s) of Measurement

Flowing Water

Flowing water conditions are found in perennial (water always present) and ephemeral (water intermittently present) streams. The location and the number of field measurements depend on study objectives. Different study objectives could dictate different methods for locating the measurement point(s). For example, field measurements designed to correlate water chemistry with benthic invertebrates may require measurements on one or more grab samples that represent populated sections of the stream channel. Generally, a single set of field measurement data is used to represent an entire stream cross section at a sampling site and can be useful when calculating chemical loads.

To locate measurement points:

USGS EWI (Equal Width Increment) and EDI (Equal Depth Increment) methods are beyond the scope of our surface water sampling programs.

Most sampling is single-point grab sampling.

Knowledge and experience must often be applied to sampling site selection in that a single sample will represent the entire stream width.

The sampling site must be well-mixed.

Backwaters, pools, and eddies must be avoided.

For safety purposes, the sample may have to be taken within arm's length or remote-sampling-pole length of the bank.

As a rule, if stream flow feet per second • stream depth (in feet) > sampler's height (in feet), Do Not Wade!

***In Situ* and Sub-Sample Measurement Procedures**

***In situ* Measurement**

In-situ measurement, made by immersing a field measurement sensor directly into the water may be used to determine parameter variability at a single stream point. *In situ* measurement can be repeated at a variety of points if stream discharge is highly variable and a single measurement point may not be as representative as the average of multiple measurement point values.

Measurements made directly in the surface water body (*in situ*) are preferable to avoid changes that result from removing a water sample from its source. *In situ* measurement is necessary to avoid changes in chemical properties of anoxic (devoid of oxygen) water.
In situ measurement is mandatory for determination of:

- Temperature,
- Dissolved Oxygen, and
- pH

In situ measurement also can be used for pH, Specific conductance, and Turbidity, but not for Alkalinity.

Sub-Sample Measurement

Depth- and width-integrated sampling methods can be used to collect and composite samples that can be sub-sampled for some field measurements. Again, these sampling methods are generally beyond the scope of our ambient surface water quality sampling programs. However, the same field measurements can be performed on discrete samples collected with a thief, a bailer, or a grab sampler. Sub-samples or discrete samples that have been withdrawn from a sample-compositing device or point sampler can yield good data for specific conductance, pH, turbidity, and alkalinity as long as correct procedures are followed and the water is not anoxic (devoid of oxygen).

Sub-samples are necessary for Alkalinity determinations.

Before using a sample-compositing/splitting device, pre-clean and field-rinse the device in accordance with approved procedures.

When compositing and splitting a sample, follow manufacturer's instructions for the device being used.

Again, do not measure temperature, dissolved oxygen, or pH on sub-samples.

Appendix G

Coliform Bacteria Sampling

Sample Collection, Preservation, and Storage

Because sterile conditions must be maintained during collection, preservation, storage, and analysis of indicator bacteria samples, specific procedures have been developed that must be strictly followed. These procedures vary with types of sampling equipment and source of sample (surface water, ground water, treated water, or waste water).

Surface-Water Sample Collection

The areal and temporal distribution of indicator bacteria in surface water can be as variable as the distribution of suspended sediment because bacteria commonly are associated with solid particles. To obtain representative data, use the same methods for collecting surface-water samples for bacteria analysis as for suspended sediment.

Quality Control.

Depending on the data-quality requirements, quality-control (QC) samples (blanks and replicates) can comprise from 5 to 30 percent or more of the total number of samples collected over a given period of time.

Collect and analyze field blanks to document that sampling equipment has not been contaminated.

Process field blanks before collecting the water sample:

- Rinse sterile sampling equipment and containers with sterile buffered water.
- Process sterile buffered water through sampling equipment and into sterile sample bottle and analyze for colony growth. If no growth is observed, the sample was collected using sterile procedures.

Hand-Dip Method

If the stream depth and (or) velocity is not sufficient to use a depth-and-width integrating method, collect a sample by a hand-dip method. Sampling still water or sampling at depth in lakes, reservoirs, estuaries, and oceans requires a sterile point sampler. Niskin, ZoBell, and Wheaton samplers hold a sterilizable bottle or bag. To collect a hand-dipped sample:

- Open a sterile, narrow-mouth borosilicate glass or plastic bottle; grasp the bottle near the base, with hand and arm on downstream side of bottle.
- Without rinsing, plunge the bottle opening downward, below the water surface. Allow the bottle to fill with the opening pointed slightly upward into the current.

- Remove the bottle with the opening pointed upward from the water and tightly cap it, allowing about 2.5 to 5 cm of headspace. This procedure minimizes collection of surface film and avoids contact with the streambed.

As with surface water, most bacteria in ground and well water are associated with solid particles. Stable values of field measurements (turbidity, temperature, dissolved-oxygen concentration, pH, and specific electrical conductance) are important criteria for judging if a well has been sufficiently purged for collection of a representative ground-water sample for indicator bacteria analysis.

Sample Preservation and Storage

After collection, immediately chill samples in an ice chest or refrigerator at ≤ 6°C. Do not freeze samples. Begin analysis as quickly as possible, preferably within 1 hour but not more than 6 hours[†] after sample collection, to minimize changes in the concentration of indicator bacteria.

Preserving Sample Cleanliness

Keep the rope, used to lower the sampler, coiled inside of a bucket. While pulling the sampler up, constantly recoil the rope into the bucket. This keeps the rope from being contaminated by substances from the bridge deck.

When lowering and raising the sampler do not let the rope rub against the side of the bridge. Such rubbing knocks material from the bridge into the sampler, and can contaminate the sample.

Safety When Sampling From a Bridge

If you are in traffic wear a traffic safety vest. Carry a white bucket to increase your visibility. If visibility is low, set a blinking warning light next to you while you are collecting the sample.

If you are on a Warner truss or similar bridge and it is a sunny day, also use a warning light. Place the light in one of the shadows. The shadows of the truss work on the bridge deck will cause optical confusion for approaching drivers and will hide your presence.

[†]MPCA Environmental Analysis & Outcomes Division policy is as follows:

The maximum 6-hour holding time must be strictly observed if the sampling is being done in conjunction with a possible enforcement action. A chain-of-custody form must also be used.

If the sampling is not for possible enforcement purposes, the maximum holding time is 24-hours and a chain-of-custody form need not be used.

Appendix H

Dissolved Oxygen Meter Calibration Log

Meter ID: _____

Date	Time	Temp (°C)	Baro-metric Pres-sure	BP (M or A)	Air Calibra-tion	Winkler Test result	Instru-ment Reading	Calib. Adj? * Y or N	Initials

*** Validity of all measurements made since last calibration check should be considered if meter reset is required.**

Dissolved Oxygen Meter Calibration Instructions

- Calibrate the instrument at or just before you arrive at the first sample site. You should have allowed at least 20 minutes for the probe to polarize. Meter should be placed in either the TEMP, DO, or RED LINE mode, but not the ZERO.
- Before staring calibration check to see that the meter still RED LINE's and ZERO's properly.
- Calibrate the meter using either the air calibration or Winkler titration method

Air Calibration

Place the probe in air at 100% humidity (wrap the probe loosely in a damp cloth, or place the probe in a calibration bottle containing a wet sponge or a calibration chamber). Do not tolerate water drops on the membrane face while air calibrating. Allow 15-20 minutes for a stable 100% humidity atmosphere to form around the membrane. Switch to "TEMPERATURE" and read. Based on the true barometric pressure or assumed altitude calculate the corrected DO calibration value (use the chart on the back of the meter). Using the "O_2 CALIB" knob, adjust the meter reading to the corrected calibration value. Leave the probe in the sample for a few minutes to verify the calibration's stability. Use the O_2 CALIB knob's locking ring to the knob. (If the just the altitude table was used, instead of readings from a reliable barometer, expect a 3-8% error in your DO readings.)

Winkler Titration

This method is selected when precise DO measurements are needed. The agency uses the sodium azide modification of the Winkler test. This modification eliminates nitrite interference. Run the Winkler test with two DO samples taken from a bucket of distilled or aged (day old) tap water. (Do not use river or lake water, since such water is impacted by aquatic plants, and therefore can be an unstable DO environment.) If possible this bucket water should be at or near the temperature of the water that you will be sampling. Use the mean of the two titrations as the calibration target. Place the DO probe and stirrer in the water bucket before taking the Winkler samples. This avoids the possibility of entraining oxygen in the bucket's water at a critical time. Run the probe's stirrer for at least two minutes before setting the calibration. Using the "CALIBRATE" dial, adjust the meter reading to the mean DO value. Leave the probe in the sample for a few minutes to verify the calibration's stability.

Table 8. Oxygen Solubility Table

Oxygen Solubility Table (elevation)

Dissolved-oxygen concentration (mg/L) in water as a function of temperature and barometric pressure (salinity = 0 ppt).

	Barometric pressure, millimeters of mercury									
Temp. (°C)	**735**	**740**	**745**	**750**	**755**	**760***	**765**	**770**	**775**	**780**
0	14.12	14.22	14.31	14.41	14.51	14.60	14.70	14.80	14.89	14.99
1	13.73	13.82	13.92	14.01	14.10	14.20	14.29	14.39	14.48	14.57
2	13.36	13.45	13.54	13.63	13.72	13.81	13.90	14.00	14.09	14.18
3	13.00	13.09	13.18	13.27	13.36	13.45	13.53	13.62	13.71	13.80
4	12.66	12.75	12.83	12.92	13.01	13.09	13.18	13.27	13.35	13.44
5	12.33	12.42	12.50	12.59	12.67	12.76	12.84	12.93	13.01	13.10
6	12.02	12.11	12.19	12.27	12.35	12.44	12.52	12.60	12.68	12.77
7	11.72	11.80	11.89	11.97	12.05	12.13	12.21	12.29	12.37	12.45
8	11.44	11.52	11.60	11.67	11.75	11.83	11.91	11.99	12.07	12.15
9	11.16	11.24	11.32	11.40	11.47	11.55	11.63	11.70	11.78	11.86
10	10.90	10.98	11.05	11.13	11.20	11.28	11.35	11.43	11.50	11.58
11	10.65	10.72	10.80	10.87	10.94	11.02	11.09	11.16	11.24	11.31
12	10.41	10.48	10.55	10.62	10.69	10.77	10.84	10.91	10.98	11.05
13	10.17	10.24	10.31	10.38	10.46	10.53	10.60	10.67	10.74	10.81
14	9.95	10.02	10.09	10.16	10.23	10.29	10.36	10.43	10.50	10.57
15	9.73	9.80	9.87	9.94	10.00	10.07	10.14	10.21	10.27	10.34
16	9.53	9.59	9.66	9.73	9.79	9.86	9.92	9.99	10.06	10.12
17	9.33	9.39	9.46	9.52	9.59	9.65	9.72	9.78	9.85	9.91
18	9.14	9.20	9.26	9.33	9.39	9.45	9.52	9.58	9.64	9.71
19	8.95	9.01	9.07	9.14	9.20	9.26	9.32	9.39	9.45	9.51
20	8.77	8.83	8.89	8.95	9.02	9.08	9.14	9.20	9.26	9.32
21	8.60	8.66	8.72	8.78	8.84	8.90	8.96	9.02	9.08	9.14
22	8.43	8.49	8.55	8.61	8.67	8.73	8.79	8.84	8.90	8.96
23	8.27	8.33	8.39	8.44	8.50	8.56	8.62	8.68	8.73	8.79
24	8.11	8.17	8.23	8.29	8.34	8.40	8.46	8.51	8.57	8.63
25	7.96	8.02	8.08	8.13	8.19	8.24	8.30	8.36	8.41	8.47
26	7.82	7.87	7.93	7.98	8.04	8.09	8.15	8.20	8.26	8.31
27	7.68	7.73	7.79	7.84	7.89	7.95	8.00	8.06	8.11	8.17
28	7.54	7.59	7.65	7.70	7.75	7.81	7.86	7.91	7.97	8.02
29	7.41	7.46	7.51	7.57	7.62	7.67	7.72	7.78	7.83	7.88
30	7.28	7.33	7.38	7.44	7.49	7.54	7.59	7.64	7.69	7.75
31	7.16	7.21	7.26	7.31	7.36	7.41	7.46	7.51	7.56	7.62
32	7.04	7.09	7.14	7.19	7.24	7.29	7.34	7.39	7.44	7.49
33	6.92	6.97	7.02	7.07	7.12	7.17	7.22	7.27	7.31	7.36
34	6.80	6.85	6.90	6.95	7.00	7.05	7.10	7.15	7.20	7.24
35	6.69	6.74	6.79	6.84	6.89	6.93	6.98	7.03	7.08	7.13
36	6.59	6.63	6.68	6.73	6.78	6.82	6.87	6.92	6.97	7.01
37	6.48	6.53	6.57	6.62	6.67	6.72	6.76	6.81	6.86	6.90
38	6.38	6.43	6.47	6.52	6.56	6.61	6.66	6.70	6.75	6.80
39	6.28	6.33	6.37	6.42	6.46	6.51	6.56	6.60	6.65	6.69
40	6.18	6.23	6.27	6.32	6.36	6.41	6.46	6.50	6.55	6.59

A barometric pressure of 760 millimeters of mercury is considered sea level.

Appendix I

pH Meter Calibration Log

Meter ID: _____

Date	Time	Temp (°C)	Reading on pH 7 buffer before reset	Expect pH 7 buffer reading	Reading on pH 10 buffer before reset	Expect pH 10 Buffer reading	Slope	Buffer exp. Date	Calib. Adj? * Y/N	Initials

*** Validity of all measurements made since last calibration check should be considered if meter reset is required.**

pH Meter Calibration Instructions

- Refer to the meter users' manual for instructions about preparing the probe for use and clean it as you would to measure a sample's pH.

- Using the probe as if measuring sample water, submerse probe in fresh pH 7 buffer water to depth recommended by the manufacturer. When the reading has stabilized, note it on the log. DON'T ADJUST THE METER TO THE PROPER READING YET. Also note the temperature reading on the meter, and write down the expected buffer pH at that temperature range, which is usually found on the side of the buffer container.

- Submerse the probe in fresh pH 10 buffer, following the same procedure and notations. (If sampling in acidic waters, use pH 4 buffer instead).

- Now rinse and re-place the probe in the 7 and 10 buffers and allow or reset the meter to re-calibrate, if needed. If the reset is manual, be sure to set the meter to the expected buffer pH at the temperature measured; usually found on the side of the buffer container.

IMPORTANT: If the calibration was off more than your project's data quality objectives allow (generally about 0.5 pH unit), be sure the project data manager, who reviews and accepts the water quality measurement results, is aware of the possible discrepancy in the data generated by the meter since the last calibration.